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DOD GATEWAY INFORMATION SYSTEM (DGIS) COMMON COMMAND LANGUAGE: THE FIRST PROTOTYPING AND THE DECISION FOR ARTIFICIAL INTELLIGENCE

Allan D. Kuhn
with
Randy L. Bixby
Duc Tien Tran (Consultant)

August 1987

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The first prototyping experiences in DGIS Common Command Language (CCL) are related. DGIS began its initial prototypes in C language with DIALOG, BRS, NASA/RECON, and DROLS. These prototypes in a third-generation algorithmic language brought to surface a number of problems and questions in dealing with the distinctions of information systems. The issues concern both the user interface and the development design. Experiences, results, and conclusions in working with these systems are brought out. The decision to convert to and continue CCL development with Artificial Intelligence tools is explained. Our effort is a merging of PROLOG and C capabilities, to provide the DGIS user an AI-based searcher assistant interface that makes the human-machine interaction more human-like on DGIS.

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DOD GATEWAY INFORMATION SYSTEM (DGIS) COMMON COMMAND LANGUAGE: THE FIRST PROTOTYPING & THE DECISION FOR ARTIFICIAL INTELLIGENCE

EXECUTIVE SUMMARY

DTIC's Common Command Language (CCL) project for the DGIS precipitated DTIC's entry into the Artificial Intelligence environment. This first report on the CCL activity relates our first prototyping experiences in CCL development. DTIC began its initial prototypes in C language with DIALOG, BRS, NASA/RECON, and DROLS. These prototypes, developed in a third-generation algorithmic language, brought to the surface a number of issues relevant to information systems and the Common Command Language concept.

These issues concern both the user interface and the development design. Experiences, results, and conclusions gained from working with these systems are explored. We have learned that creating a standard command language is only a minor part of the challenge we face. The major challenge involves accomodating the operating characteristics of the individual systems.

The creation of a CCL is only one component of the "CCL-need" issue. A second component is creation of a CCL System that allows a user to search in unfamiliar systems without needing to know a system's operating characteristics. A third component is identifying the critical objectives that a CCL System is to serve. In the case of DGIS, the criteria for CCL objectives are the DGIS information processing operations.

The decision to convert to and continue our CCL development with Artificial Intelligence tools is explained. PROLOG was chosen because it is a simple but powerful relational programming language based on the concept of programming in logic. Our effort merges PROLOG and C capabilities, to provide the DGIS user an AI-based searcher assistant interface. The purpose of this interface is to make the human-machine interaction more human-like on DGIS.

With the transition to an AI-based CCL System, the goals of DGIS CCL were re-constituted to incorporate AI-driven capabilities as follows:

- Standardize a command language to communicate with all bibliographic databases.
- Create a CCL System that assists the user in searching unfamiliar database systems.
- Provide the means for a user-friendly search session.
- Provide the means for an intelligent, user-useful search session.
- Have flexibility to adapt easily to changes and enhancements.

CONTENT

DOD GATEWAY INFORMATION SYSTEM (DGIS) COMMON COMMAND LANGUAGE: THE FIRST PROTOTYPING & THE DECISION FOR ARTIFICIAL INTELLIGENCE

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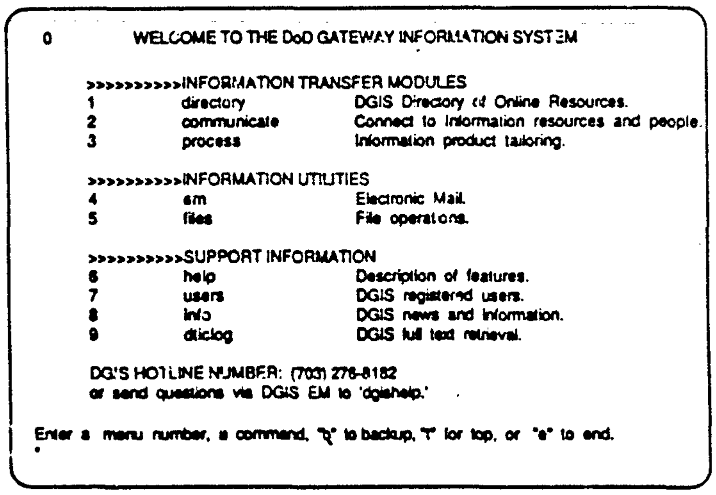
I. INTRODUCTION

The Defense Technical Information Center (DTIC) of the U.S. Department of Defense (DoD) has sponsored development of a DoD Gateway Information System (DGIS) since 1982. The purpose of DGIS is to provide online, streamlined methods for identifying, accessing, searching and analyzing data from heterogeneous databases of interest to the DoD community [CGA85]. The following figure is the top menu of DGIS, and shows its core operations to achieve this purpose [KAD86]:



```
0          WELCOME TO THE DoD GATEWAY INFORMATION SYSTEM

      >>>>>>>>>>INFORMATION TRANSFER MODULES
      1         directory       DGIS Directory of Online Resources.
      2         communicate     Connect to Information resources and people.
      3         process         Information product tailoring.

      >>>>>>>>>>INFORMATION UTILITIES
      4         em              Electronic Mail.
      5         files           File operations.

      >>>>>>>>>>SUPPORT INFORMATION
      6         help            Description of features.
      7         users           DGIS registered users.
      8         info            DGIS news and information.
      9         dticlog         DGIS full text retrieval.

      DGIS HOTLINE NUMBER: (703) 276-8182
      or send questions via DGIS EM to 'dgishelp.'

Enter a menu number, a command, "b" to backup, "t" for top, or "e" to end.
*
```

Present-day access to information resources is constrained, since each database system has its own complex access procedure and command language. Additionally, results from multiple databases cannot be combined or analyzed easily by the user. The DGIS provides DoD researchers and managers access to many different databases using a single, simple access procedure. The system has a library of automated routines by which the user may reformat, analyze, and tailor aggregated information into a form useful to the enduser [CGA86]. The intent of DGIS is to provide the user a useful tool to collect, process and transfer information.

II. BACKGROUND

One of the primary development goals of the DGIS was to design and implement a common command language (CCL). The prototype DGIS, established in January, 1986, provides access to a multitude of information systems. But the user must know the native command language and operating characteristics of each system. The Program Manager for the DoD Gateway Information System (DGIS) assigned a Common Command Language(CCL) design activity in April 1986.

A team of three people began the effort. The team consisted of a project manager, a computer systems analyst/programmer, and a technical information specialist. The technical information specialist was responsible for researching and defining the command language information requirements. This information would be used by the programmer to program the CCL software.

The Project Officer defined the boundaries and objective of the CCL as follows:

1. The mission of DGIS is to provide uniform access to remote, diverse databases, aggregate information from those databases, and provide post-processing routines. The end product of the DGIS will be an information product that is tailored to meet the needs of the user.

2. A widely recognized problem in accessing multiple diverse databases is the absolute requirement to search and retrieve information from them in their idiosyncratic command languages. This requirement forces the searcher to learn the native command languages of different database systems in order to acquire a comprehensive set of information.

3. The Objective of the DGIS Common Command Language project, therefore, is to determine, formulate, and structure a DGIS common access approach that facilitates access to multiple databases in a unified manner.

4. DGIS CCL will be optional, at the discretion of the user; if the user so desires, native command language searching is available.

5. Various CCL modes are to be explored including:

   (1) Formulation of a DGIS CCL command set.

   (2) The ability to search any database system with the native language of a system already familiar to the searcher. In this case, the DGIS CCL serves as a transparent conversion mechanism.

   (3) Query languages, forms and methods provided by the fourth generation languages and artificial intelligence.

5. The DGIS Common Command Language development team will monitor developments of other organizations, especially that of the National Information Standards Organization (NISO) and its Subcommittee G for Common Command Language for Online Interactive Information Retrieval.

III. PROJECT CONCEPT AND MODULES

1. CONCEPT ELEMENTS

As we developed the project concept the complexity of the activity became apparent. We organized the activity in a modular structure for easier management, as follows.

Requirements Development Module
Common Access Development Module
CCL Standards Module

The Requirements and Access development modules evolved into high activity, distinct development environments. The Standards module evolved into a support function requiring only periodic activity.

The plan of action was formulated to take advantage of all DGIS capabilities. For example, in addition to CCL access to the information systems, such as DIALOG, BRS, and DROLS, we wanted CCL access to those systems for which we had postprocessing routines already established through parallel DGIS projects. For the most part, these were the same systems. The DGIS CCL project activity, therefore, was planned as follows:

THE REQUIREMENTS DEVELOPMENT MODULE

The database sets of commonly used commands, i.e., those most frequently required by the user community, were identified. This established a core set of common function commands. This module then entailed:

a. Mapping the commands/functions of the initial DGIS-targetted databases:

    Defense RDT&E On-Line System (DROLS) (Dept. of Defense)
    Work Unit Information System (WUIS) (Dept. of Defense)
    Manpower and Training Information System (MATRIS) (Dept. of Defense)
    DOE/RECON (Dept. of Energy)
    NASA/RECON (National Aeronautics and Space Administration)
    DIALOG
    BRS
    ORBIT

b. Designing a DGIS common command language structure. The design was to incorporate standards. This activity was to define the syntax and semantics of a native command language, and bridge it to the Common Command Language.

c. Designing command language translators. This was to be based on merging the mapping requirements with the DGIS UNIX operating system C language programming capabilities.

d. Designing the DGIS Common Command Language communication software for interacting with the target information systems.

COMMON ACCESS DEVELOPMENT MODULE

In this module we explored the potential applications of fourth generation languages and artificial intelligence. We identified their potentials for creating uniform methods of searching in and retrieving from diverse databases. This included screens, utilities, menus, windows, query organizing, natural language, knowledge base systems, et al. These technology applications could provide the capability for true simultaneous searching in multiple databases. We partitioned this development into two phases:

Phase 1 (Near Term): Establishment of single database searching.
Phase 2 (Long Term): Establishment of simultaneous database searching.

CCL STANDARDS MODULE

The intent of this module was to track national and international CCL standards for use in our DGIS CCL effort. We opted to follow the common command language standard adopted by the U.S. National Information Standards Organization (NISO). We were to track CCL activities by:

a. Liaison with NISO.
b. Participation in CCL activities at conferences and meetings.
c. Determination of the applicability of CCL standards to DGIS CCL.
d. Liaison with organizations actively involved in CCL developments and applications.

The modules described above provided the building blocks of the project.

2. MODULE DEVELOPMENT

STANDARD CCL: We adopted the NISO Draft Standard to serve as the foundation of the DGIS CCL. The standard was very useful not only because the online searching functions were labeled, but also the 1987 draft version included the Backus-Naur Form (BNF) for the command language syntax [NISO87]. We also provided comments on the 1986 draft to NISO.

MAPPING: We learned very early that we were not dealing with commands, but with functions. Mapping involved identifying the functions, and making the bridge between the database function label and the CCL function label. Intensive reviews of database functions, commands and operating characteristics have been made by the technical information specialist, and continue to be made by her as we progress from one database to the next. This activity, of course, has made this person a valuable and knowledgeable database resources expert.

We partitioned the functions and their commands into three groups. Group assignment was made by criticality and frequency of use [BRL87]. These groups are:

Group I: Most commonly used, basic functions.
Group II: Remaining common functions.
Group III: Database Idiosyncratic functions.

The selection for Group I was based on the following criteria:

a. Common to all databases.
b. Essential for a complete search and retrieval session.
c . Small enough group so that several working prototypes could be programmed within a reasonable length of time, e.g., four to six months.

The NISO commands START, CHOOSE, FIND, DISPLAY, and STOP were selected to form Group I. DGIS already had automatic connects and disconnects established, however, leaving only CHOOSE, FIND, and DISPLAY to analyze. The CCL elements associated with Group I are shown in the table below, from the perspective of the CCL user [KAD87]:

DGIS	NISO	Diverse Databases	
Automatic Connect	START	[Logon Routines]	
	CHOOSE	DIALOG:	b
		DROLS:	@s[database name]@
		ORBIT:	[file name]
		NASA:	b, bb
		BRS:	change/ [database name]
	FIND	DIALOG:	s, ss
		DROLS	@s[database name]@
		ORBIT:	[search term]
		NASA:	s
		BRS:	..s
	DISPLAY	DIALOG:	t
		DROLS:	@dsr@
		ORBIT:	print
		NASA:	d
		BRS:	..p
<ESC><CONT>d	STOP	DIALOG:	logoff
		DROLS:	@term@
		ORBIT:	stop
		NASA:	signoff
		BRS:	..o

Table: Comparison of CCL and Native Command Language Examples.

The command function set for Group II is lengthy, but the primary objective was first to validate the working prototypes based on the Group I commands, and then add on the remaining functions. Group II, therefore, is comprised of (and informally broken down as):

(a)	(b)	(c)
SCAN	PRINT	EXPLAIN
MORE	REVIEW	HELP
BACK	SORT	SHOW
RELATE	SAVE	SET
	DELETE	DEFINE

Group III, idiosyncratic commands, are those peculiar to the individual systems and without a common command standard. Our 'pro tempore' solution for those commands was to allow the user to switch into database native command language mode. This decision is subject to further analysis.

COMMON ACCESS: We made a preliminary review of Fourth Generation Language (4GL) capabilities. An important reason for this review was that the DGIS Directory of Online Resources [JCE86], a component of the DGIS software, is being developed on the INGRES DBMS. Through the Directory, users can search by subject for databases that are relevant to their queries. Eventually DGIS CCL will be interfaced with the Directory so that once the relevant databases are determined by the Directory, a user's query will be automatically filtered through the CCL capability to search those databases simultaneously.

We looked at INGRES 4GL features, such as query organizing, query-by-form, windowing, database building relative to CCL, forms generating, etc. We concluded that 4GL aplicatins might be useful in advanced CCL versions, but initial emphasis was to develop a prototype CCL as quickly as possible. We decided, therefore, to concentrate on C language prototype programming with the purpose of validating simple prototypes and then pursuing more advanced features. The decision turned out to be fortuitous, for later we made the jump to artificial intelligence applications 'vis-a-vis' 4GL.

IV. OUR FIRST PROTOTYPING DEVELOPMENTS

Our initial effort to implement CCL was involved selecting simple approach, and trying to get several prototypes up quickly. Once in place, we could then experiment with them and learn from our experiences. Programming was done in C, merged with two UNIX utilities that were immediately adaptable to CCL needs. Those two utilities were LEX (generator of lexical analysis programs), and YACC (Yet Another Compiler-Compiler) [UNIXol]. LEX was used for lexical analysis of the CCL prototype C programs, YACC for the syntactical analysis. C was used to implement all remaining semantic processing and miscellaneous tasks. [TDTpip]

Communications was a highly critical element. We needed some type of communications program to talk with databases. DGIS had NAM (Network Access Machine) software agents available in the DGIS software for connecting users to databases for native language searching. A technical review was made of the software, and it was ascertained that it provided the needed capabilities for communicating with remote databases in CCL. NAM provided a utility for:

a. Establishing the connection.
b. Validating user access.
c. Logging on to the target database, including entry of the logon codes.

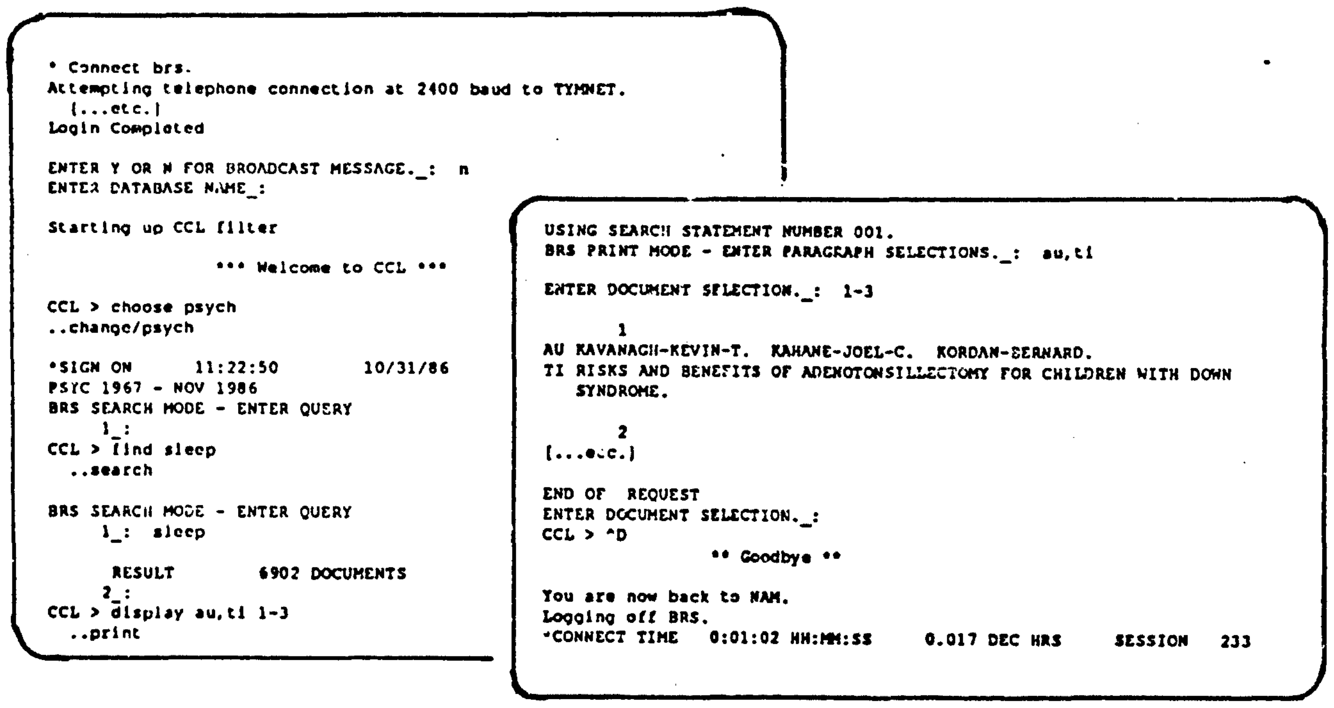
The NAM agent was adapted to CCL, therefore, for communicating the command and response in searching the remote database system. [TDTpip]

V. THE FIRST PROTOTYPES

Our first prototype, achieved five months after beginning the effort (August 1986), was DGIS CCL for DIALOG. DIALOG was chosen because it was a system with which many users in the DoD community are familiar, and find easy to use.

The DIALOG prototype was followed by BRS, NASA-RECON, and DROLS in fairly rapid succession. BRS was chosen because it was a another major vendor system with many databases, NASA-RECON because it was a Federal government database system, and finally DROLS, DTIC's database system.

The following, a BRS session, shows how the CCL BRS prototype works. Please note that at this stage, CCL is only a substitute for BRS native commands. Other than the commands, BRS must be addressed on its terms. The CCL invocations are indicated by the prompt 'CCL >'. The line following this prompt is the BRS command entry, which echoes the CCL entry:



```
* Connect brs.
Attempting telephone connection at 2400 baud to TYMNET.
  [...etc.]
Login Completed

ENTER Y OR N FOR BROADCAST MESSAGE._:  n
ENTER DATABASE NAME_:

Starting up CCL filter

                *** Welcome to CCL ***

CCL > choose psych
..change/psych

*SIGN ON      11:22:50          10/31/86
PSYC 1967 - NOV 1986
BRS SEARCH MODE - ENTER QUERY
     1_:
CCL > find sleep
  ..search

BRS SEARCH MODE - ENTER QUERY
     1_:  sleep

      RESULT        6902 DOCUMENTS
     2_:
CCL > display au,ti 1-3
  ..print
```

```
USING SEARCH STATEMENT NUMBER 001.
BRS PRINT MODE - ENTER PARAGRAPH SELECTIONS._:  au,ti

ENTER DOCUMENT SELECTION._:  1-3

         1
AU KAVANAGH-KEVIN-T.  KAHANE-JOEL-C.  KORDAN-BERNARD.
TI RISKS AND BENEFITS OF ADENOTONSILLECTOMY FOR CHILDREN WITH DOWN
   SYNDROME.

         2
[...etc.]

END OF  REQUEST
ENTER DOCUMENT SELECTION._:
CCL > ^D
                    ** Goodbye **

You are now back to NAM.
Logging off BRS.
*CONNECT TIME   0:01:02 HH:MM:SS     0.017 DEC HRS     SESSION   233
```

- CCL in BRS -

In addition to showing CCL command application, this session is also an example of the need to still know the individualistic operating characteristics of an information system.

VI. FIRST PROTOTYPE RESULTS

We terminated C-programming with completion of the four prototypes. The experience we gained was immeasurably useful. The following issues and features resulted from this first prototyping:

1. The Adaptation of the NAM Connection Agent: As mentioned above, NAM software for connecting with remote databases was already available. Once the sign-on is completed, the user is connected directly with the database. The

user then invokes the CCL translator.

2. CCL Invocation: Currently, once one has accessed a database system through the NAM connection agent, one may invoke the CCL translator with a special key.

3. CCL Translators: The creation of prototype CCL translators taught us that each information system is individualistic and must be treated as such. The translator programming is totally dependent on the mapping requirements for each system. The programmer must also detect anything "hidden" in the target database system that is needed for a response. The CCL translator is a filter that is toggled on and off by a special key. Once activated, it intercepts all CCL commands from the user, translates the command, sends the translation (i.e., the target database native command) for execution, and brings the results back to the user [TDTpip]. The translator is deactivated by the conventional <CNTL>d (exit from a process).

4. Native Command Language Option: The option to use the native command language was necessary when we were prototyping only the basic commonly used commands (Group I already mentioned). The entry of a native command was made very simple: at the CCL prompt, one precedes the native command with a backward slash (\) to tell the translator that the native command is coming, e.g.,

```
CCL >  \s     (for DIALOG 'select')
```

5. The CCL Prompt: The prompt 'CCL >' was incorporated as a reminder to the user that one has invoked the CCL utility.

6. CCL Command Verification: When the user invokes a common command, the translation of the invocation is echoed in the database system structure, e.g., for DROLS:

```
                    CCL > find artificial intelligence and psychology

         (echo)       @str@
                      artificial intelligence
                      and
                      psychology
                      end

                    CCL: Searching...
```

The echo may also be turned off, currently with the command: CCL> noecho .

7. Online Documentation: The HELP feature to show the user how to use the CCL. The documentation, in very abbreviated form, covers the CCL commands available. For example (DIALOG):

```
CCL > help find

        CCL format
                 find <term> ...
        DIALOG2 format
                 select <term> ...
        DESCRIPTION
                 Initiate a search.
```

8. Shell Spawning while in CCL: We incorporated the capability to exploit a UNIX shell, file, or utility while in the CCL. Use of the capability is at the user's discretion; for example, the user may want to list one's files as a review measure while searching a database. The signal to the CCL translator is an initial bang (!), e.g.,

```
CCL > !ls      (for listing files)
CCL > !w       (for seeing who is on the system)
   etc.
```

9. New Commands: In developing the DGIS CCL we found that the NISO standard did not cover several items that we deemed useful. Usefulness was based on the following criteria:

a. Functions, prevalent in systems, that aided the user; an example is successive session cost display.
b. Functions, not prevalent, seen as highly useful; e.g., listing the accession numbe s of finds.
c. Functions that we found were needed for an operative CCL; an example is cancelling the translation echo display at one's discretion.

The non-NISO commands that we incorporated under the first prototyping are:

COMBINE	Do Boolean operations (and, or, not) on previously created sets.
COST	Display session cost thusfar.
EXECUTE	Execute a previously saved search strategy (in target database).
LIST	List accession numbers of search results.
NOECHO	Cancel native command function echo to CCL command function.

10. NISO Standard Common Commands Incorporated in the First Prototyping: As we developed the four prototypes, we added on commands to enhance the prototype capabilities. We used, therefore:

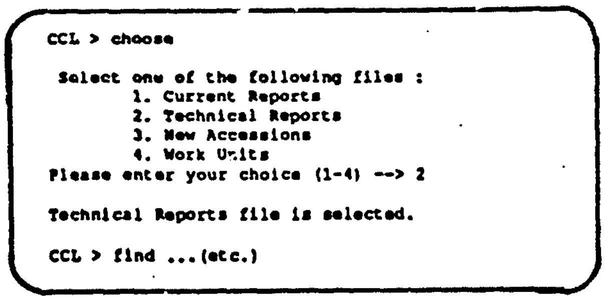
CHOOSE (Group I)
HELP (for target database help)
FIND (Group I)
DISPLAY (Group I)
RELATE
MORE -- in NISO 86, changed to FORWARD in NISO 87.
BACK

The standard START and STOP (Group I) are taken care of by the DGIS automatic connect and disconnect.

11. CCL System Menu Development: As we progressed through the four prototypes, the systems became more terse. We were exposed to many unique features. The programmer was totally unfamiliar with DROLS which is a terse, no-assist system with access limited to a strictly controlled user community. As a skillful programmer he was, therefore, an ideal person to look at DROLS and determine its appropriate functional CCL requirements.

The very terseness of DROLS (including that lack of a prompt) generated the need to experiment with menu sets to step the unfamiliar user through the database. These menus, basically, provide functional information the expert DROLS searcher knows, but is not on the system. CCL menu examples are:

When invoking CCL CHOOSE in DROLS without designating which database -



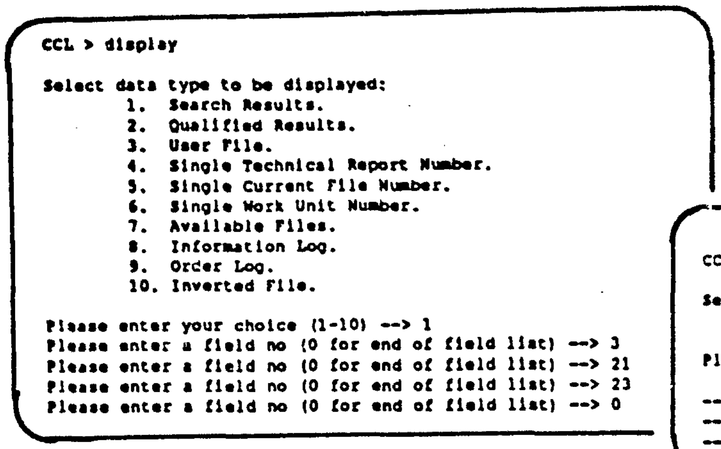
```
CCL > choose

 Select one of the following files :
        1. Current Reports
        2. Technical Reports
        3. New Accessions
        4. Work Units
Please enter your choice (1-4) --> 2

Technical Reports file is selected.

CCL > find ...(etc.)
```

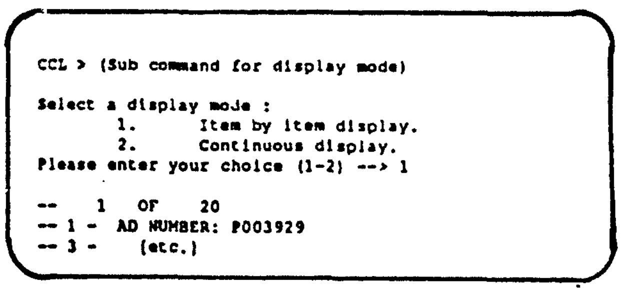
When invoking CCL DISPLAY for search results in DROLS without designating a display format -



```
CCL > display

Select data type to be displayed:
        1.  Search Results.
        2.  Qualified Results.
        3.  User File.
        4.  Single Technical Report Number.
        5.  Single Current File Number.
        6.  Single Work Unit Number.
        7.  Available Files.
        8.  Information Log.
        9.  Order Log.
        10. Inverted File.

Please enter your choice (1-10) --> 1
Please enter a field no (0 for end of field list) --> 3
Please enter a field no (0 for end of field list) --> 21
Please enter a field no (0 for end of field list) --> 23
Please enter a field no (0 for end of field list) --> 0
```



```
CCL > (Sub command for display mode)

Select a display mode :
        1.      Item by item display.
        2.      Continuous display.
Please enter your choice (1-2) --> 1

--    1   OF     20
-- 1 -  AD NUMBER: P003929
-- 3 -     (etc.)
```

The inclusion of the menu sets aids the CCL user to navigate the unfamiliar system, and hopefully helps eliminate the need to totally rely on user manuals.

VII. MAJOR PROBLEM

Each prototype raised issues and problems which we used to refine the successive prototype. As the prototypes progressed, various problems in working with them lead to solutions such as HELP features and menus as mentioned above.

The major problem, however, surfaced as a result of our cumulative experience. We learned that creating "Common Command Language" was NOT a panacea. Programming a "standard" command language was in actuality only substituting one command language for another.

This was most apparent when the DISPLAY function is employed. Quite factually, if the user does not know the DISPLAY formats of an unfamiliar system, one cannot see results. A command with less knowledge requirements is the FIND function. Using FIND, the user is very likely to be able to enter the query and foment results. But any function involving a display is likely to be dead-ended in no display. Substituting CCL for th native command language simply does not obviate the need for referral to a system's user documentation, which gives instruction in terms of its native command language.

Another example is the CHOOSE function. Some systems identify databases by number, others by acronym. For BRS, one must enter CHOOSE NTIS; in DIALOG, CHOOSE 6. The hydra of options and formats keeps cropping up. Each system must be addressed individually, with the goal of having some central pattern program to draw upon. The crutch we have used for the C language-based CCL prototype is the menu.

The creation of a CCL is only one component of the "CCL-need" issue. A second component is creation of a CCL System that allows a user to search in unfamiliar database systems without needing to know that system's operating characteristics. A third component is identifying the critical purposes that a CCL system is to serve.

In the case of DGIS, the critical CCL purposes are defined by understanding the DGIS information processing operations, particularly in postprocessing downloaded files. A DGIS postprocessing requirement is to have a tagged citation for translation. Downloaded citations must be translated into the

DGIS standard citation format before the automated processing routines can be applied.

This necessity is an example of a criterion for a DGIS CCL system. The CCL system must include function default results for those users unfamiliar with a database, particularly for DISPLAY. The default, on simple invocation of DISPLAY, will provide the fully tagged citation. Additional elements, such as menus and question prompts, e.g., "DISPLAY on last set? y/n," must also be incorporated.

The case of CHOOSE represents another problem environment. In DGIS the solution is the eventual integration of CCL with the Directory of Online Resources. When this is accomplished, the query will be forwarded automatically to the relevant databases through CCL.

The real demon for CCL has turned out to be the idiosyncratic operating characteristics of each database system.

VIII. THE DECISION FOR ARTIFICIAL INTELLIGENCE

1. THE CAUSE

The rigidity and constraints of a straight algorithmic program-based CCL discovered during the prototypings lead us to exploring the potential of artificial intelligence. The natural language and expert system possibilities of AI were very appealing. The project's programming technical expert, in having an amount of AI background, reviewed the main AI programming languages. His recommendation was to explore AI applications with PROLOG, a simple but powerful relational programming language based on the idea of programming in logic [BA-86].

The initial technical reasons for selecting PROLOG were [TDTpip]:

a. The Reversibility of PROLOG <<>> In determining object relationships, a program can be written establishing those relationships, with the inverse of the relationship inherent in the program.

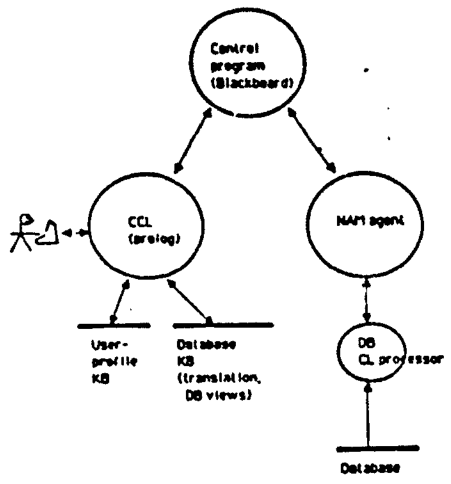
b. Its Database Capability <<>> In that PROLOG has its own internal databases, this feature allows a PROLOG program to manipulate codes as relations that can be asserted or deleted. PROLOG incorporation in CCL includes extending to external databases, e.g., INGRES DBMS in the DGIS software, to achieve the flexibility of storing knowledge in both PROLOG internal databases and traditional external databases. This allows including more powerful database technology in the program system for greater performance and easier use of DGIS by the enduser.

c. The Separation of Logic and Control <<>> A PROLOG program amalgamates rules and facts, basically making one also the other. Although they are governed by a default execution control, the control can be easily supplemented or replaced by more powerful meta-rules also coded in PROLOG.

d. Object Inheritance and Message Passing <<>> These are two powerful features of object language methodology. Both are easily implemented and embedded in PROLOG. Both features are elemental for the more graceful functioning of CCL.

2. THE CONCEPTUAL RESTRUCTURING OF CCL

Using C language programming, the basic CCL elements consisted of the user, the CCL, the database language processor, and the database information accessed. The jump to PROLOG opened new possibilities in which CCL now could be developed as a knowledge-based system. The CCL conceptual structure now became [TDTpip]:


Control program (Blackboard)
CCL (prolog)
NAM agent
User-profile KB
Database KB (translation, DB views)
DB CL processor
Database

CCL as a knowledge-based system

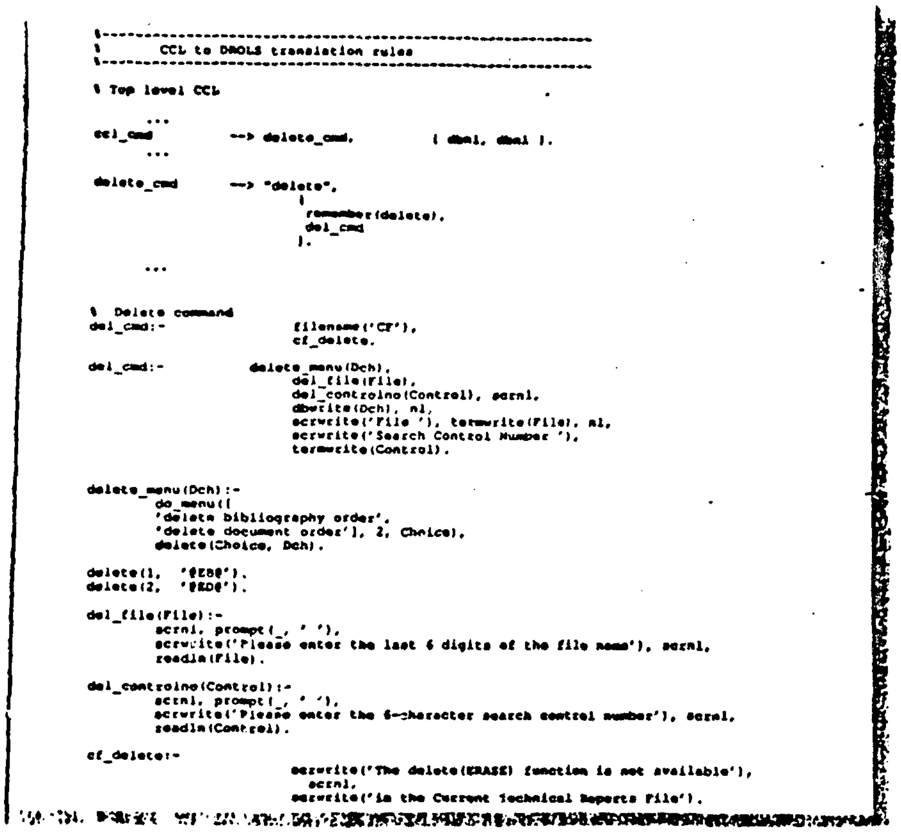
To the DGIS user making use of CCL, the fact that CCL will be PROLOG-driven is transparent. The PROLOG CCL, however, in serving the user, will draw on the command language knowledge base, and also a CCL-user profile knowledge base (still to be developed). The user's query and profile data will be controlled through the control program blackboard, which will coordinate translation and communications in a continuous real-time system mode [BA-86] through the NAM connection agent. The NAM agent passes the communications to and from the target database system's command language processor for searching on the database information.

With the transition to an AI-based CCL Systems, the goals of the DGIS CCL have been re-constituted to incorporate AI-supported capabilities as follows:

a. One command language to communicate with all bibliographic databases.
b. Creation a CCL System that assists the user in searching unfamiliar database systems.
c. Provision of a user-friendly search session.
d. Provision of an intelligent, user-useful search session.
e. Flexibility to adapt easily to changes and enhancements.

3. OTHER CHANGES IN THE ACTIVITY

Because of the relative ease of learning PROLOG programming, another effect of making the transition to PROLOG was to transfer much of that programming from the technical expert to the requirements expert. This change was made at the suggestion of the technical expert. The requirements expert took the training provided by the PROLOG vendor, and began PROLOG programming under the tutelage of the technical expert. This change gave her fuller control of the command requirements, from command language researching to command language knowledge base building. This also allowed the technical expert to concentrate on the knowledge base - database system connector programs, in itself a programming-intensive activity. The following is a small taste of the CCL knowledge base PROLOG programming, for the CCL DELETE command relative to DROLS:



```
%----------------------------------------------------------
%       CCL to DROLS translation rules
%----------------------------------------------------------

% Top level CCL

        ...
ccl_cmd          --> delete_cmd,          { dbml, dbml }.
        ...

delete_cmd       --> "delete",
                          {
                           remember(delete),
                           del_cmd
                          }.

        ...


%  Delete command
del_cmd:-                      filename('CF'),
                               cf_delete.

del_cmd:-              delete_menu(Dch),
                               del_file(File),
                               del_controlno(Control), scrnl,
                               dbwrite(Dch), nl,
                               scrwrite('File '), termwrite(File), nl,
                               scrwrite('Search Control Number '),
                               termwrite(Control).


delete_menu(Dch):-
          do_menu([
          'delete bibliography order',
          'delete document order'], 2, Choice),
          delete(Choice, Dch).

delete(1,  '@EB@').
delete(2,  '@RD@').

del_file(File):-
          scrnl, prompt(_, ' '),
          scrwrite('Please enter the last 6 digits of the file name'), scrnl,
          readln(File).

del_controlno(Control):-
          scrnl, prompt(_, ' '),
          scrwrite('Please enter the 6-character search control number'), scrnl,
          readln(Control).

cf_delete:-
                               scrwrite('The delete(ERASE) function is not available'),
                                 scrnl,
                               scrwrite('in the Current Technical Reports File').
```

This PROLOG programming sample is for the CCL DELETE command relative to DROLS in the command language knowledge base. The knowledge base in development as of July 1987 is 10 regular pages long.

4. FUTURE DIRECTIONS

Our next phase in CCL is a melding of PROLOG implementation, expert system building, and C supplementary programming. The PROLOG-based CCL has two parts [TDTpip]. One part is fixed, in compiled PROLOG code; the second is variable, in interpretive PROLOG code. The variable part loads and processes information from the two knowledge bases (KB), the command language KB and the user profile KB. Appropriate tools will be incorporated to maintain the KBs (adding, deleting, modifying information). We are currently (August 1987) procuring an artificial intelligence processor system and an expert system building software tool. The processor will be networked to the DGIS computer system, and will serve to both develop and maintain AI applications in CCL and other AI applications on DGIS [KAD87b].

We are investigating several schemes for KB organization. In general, we plan to couple PROLOG with a Relational DBMS (RDBMS) where large KBs (most of which are facts) will reside. The technical issue here is the interface between PROLOG and the RDBMS (likely INGRES). We intend to make this interface through SQL (standard query language) so that it can work with any RDBMS, rather than only with INGRES. [TDTpip]

Other CCL system factors are:

a. CCL Integration with Other DGIS Functions <<>> Other DGIS operations are potentials for AI applications, with which to link with CCL. One is the DGIS Directory of Online Resources, wherein a user's query resources are identified and communicated with automatically and simultaneously. Another is the DGIS postprocessing routines, with which the multiple resource responses are automatically downloaded, translated, merged, and processed (or tailored), based on a one-pass instruction entry with which the user invokes the whole process.

b. Planning Capability <<>> Includes the preliminary structuring of multiple queries and the combining of target databases' result sets.

c. Learning Capability for CCL <<>> Employing learning solution paths [BA-86] for optimizing the information added to the command language KB and the user profile KB.

d. Migrate to Natural Language <<>> The NISO and appended CCL will be the backbone of the DGIS CCL, but in migrating to Natural Language dialogue, will become transparent in a command language translation supporting role.

e. Provide Simultaneous Database Access Capability <<>> That is, true concurrent connecting with, searching in, and downloading of results from multiple systems.

All this to bring about the resolution of, as the technical information specialist states [BRL87]: "The problem of multiple command languages has plagued online searchers since the creation of the second online database."

<<< >>>

The appendices that follow show examples of C and PROLOG prototypes. The last appendix lists the NISO CCL commands.

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APPENDIX A

DIALOG C PROTOTYPE

dialog.c 1

```
Date: Thu Sep 11 09:47:29 1986
From: duc (Duc Tran)
Subject: note on how to run the CCL-DIALOG2

                SHORT NOTE ON HOW TO RUN THE CCL-DIALOG2 TRANSLATOR

        The CCL-DIALOG2 translator is built as an input filter to NAM.
In order to invoke this filter the user must first invoke the NAM agent that
does the connection to DIALOG2. This is done by typing:

                % nam ccldiag

        After connecting to DIALOG2 the user is, by default, talking to
DIALOG2 in its native command language. The standard DIALOG2 prompt of
question mark "?" appears at each line of input. The CCL translator is
activated only by the two key sequence ESC ^T. A CCL message displays:


                  Welcome to CCL
                Type
                     help ccl

                for the current status


At this point the user can enter one CCL command per command line.
The CCL prompt is:

                CCL >

The first time user should type

                CCL > help

to learn how to use the CCL commands.

Remember that at this point all the input from the user will go though CCL.
The valid CCL commands are translated into DIALOG2 and sent to DIALOG2 for
excution.

Native DIALOG2 commands can be accepted if a backslash (\) is detected as the
first input character at the CCL command line.

A shell process can be started if a bang (!) is entered at the CCL prompt as
the first character of the command entry.

CCL exits when a ^D is detected; control is given to NAM.
One may then continue with the native DIALOG2 commands, or exit NAM by ESC ^D .

        A sample session:

                CCL > help ccl
                CCL > help
                CCL > help help
                CCL > choose 1
                CCL > find computer
                CCL > relate computer
                CCL > more
                CCL > back
                CCL > !ls -l
                CCL > display s1
                CCL > \select education
                CCL > ^D
```

APPENDIX B

DROLS C PROTOTYPE

```
drols.c2                                                   1

Date: Fri Mar 13 08:34:23 1987
From: duc (Duc Tran)
Subject: more on DROLS

Allan:

        I have a better 'saveon' CCL-DROLS for you. Note that:

                - the 'choose' command without argument or with
                  wrong arg. (file) is presented with a menu of
                  file names.  If user uses the correct file name as
                  the argument of 'choose' then the menu is not presented,
                  just the confirmation message.

                - the 'list' command is added to CCL to map it to
                  LSR of DROLS which I think is useful.

                - 'more' for next display.

        The ccldrols is installed. You can try it by typing

                % nam ccldrols

        Remember once connection is made use ESC ^T to invoke CCL.

        Thus CCL-DROLS is now demonstrable .

        ============== saveon starts here ======================
Saveon transcript started on Fri Mar 13 08:19:06 1987
1 % nam ccldrols




Attempting telephone connection at 1200 baud to DROLS.

Dialing...
Dialing done.
Connection established to DROLS.

Login complete.


--                RDT+E ON-LINE SYSTEM    MAR 13, 1987

--PLEASE ENTER YOUR TERMINAL IDENTIFICATION
.
--            WELCOME ON LINE - DATE 031387 TIME 081957

--IF YOU DISPLAY ENTRIES OF REPORTS WITH REFERENCES MARKED
--EXPORT CONTROL THE FOLLOWING WARNING APPLIES:
--************************WARNING*************************
--THIS DOCUMENT CONTAINS TECHNICAL DATA WHOSE EXPORT IS
--RESTRICTED BY THE ARMS EXPORT CONTROL ACT (TITLE 22, U.S.C.,
--SEC. 2751 ET SEQ.) OR EXECUTIVE ORDER 12470.  VIOLATIONS OF
--THESE EXPORT LAWS ARE SUBJECT TO SEVERE CRIMINAL PENALTIES.
--DISTRIBUTION OF THIS DOCUMENT IS SUBJECT TO DODD 5230.25
--PROCEDURES
--************************WARNING*************************


Starting up CCL filter

                *** Welcome to CCL ***

                Type

                        help ccl

                for current CCL status.
CCL > choose

 Select one of the following files :
        1. Current Reports
        2. Technical Reports
        3. New Accessions
        4. Work Units
Please enter your choice (1-4) --> 2

Technical Reports fila is selected.

CCL >
CCL > choose Technical Reports

Technical Reports file is selected.

CCL > find Artificial Intelligence and Psychology
CCL: Searching...
@STR@
Artificial Intelligence
and
Psychology
END


--YOUR SEARCH STRATEGY RESULTED IN        20 FINDS


CCL > list
@LSR@


--SEARCH LIST - TECHNICAL REPORTS FILE        PAGE   1  OF    1
--              ADP003929
--              ADE801452
--              ADB108147
--              ADB092799
--              ADB092130
--              ADB045705
--              ADB018174
--              ADA175068
--              ADA171423
--              ADA163865
--              ADA150501
--              ADA146081
--              ADA138208
--              ADA127132
--          ADA103311
--          ADA101200
--          ADA100138
--          ADA048196
--          ADA036977
--          ADA036915
--

CCL > noecho

CCL > display

Select data type to be displayed:
        1.  Search Results.
        2.  Qualified Results.
        3.  User File.
        4.  Single Technical Report Number.
        5.  Single Current File Number.
        6.  Single Work Unit Number.
        7.  Available Files.
        8.  Information Log.
        9.  Order Log.
        10. Inverted File.

Please enter your choice (1-10) --> 1
Please enter a field no (0 for end of field list) --> 3
Please enter a field no (0 for end of field list) --> 21
Please enter a field no (0 for end of field list) --> 23
Please enter a field no (0 for end of field list) --> 0

CCL > (Sub command for display mode)

Select a display mode :
        1.      Item by item display.
        2.      Continuous display.
Please enter your choice (1-2) --> 1

--    1   OF    20
-- 1 -  AD NUMBER: P003929
-- 3 -  ENTRY CLASSIFICATION:   UNCLASSIFIED
--21 -  SUPPLEMENTARY NOTE:     THIS ARTICLE IS FROM 'ARTIFICIAL
--      INTELLIGENCE IN MAINTENANCE: PROCEEDINGS OF THE JOINT SERVICES
--      WORKSHOP HELD AT BOULDER, COLORADO ON 4-6 OCTOBER 1983,' AD-A145
--      349. P227-255.
--23 -  DESCRIPTORS:      *ARTIFICIAL INTELLIGENCE, *ELECTRONIC EQUIPMENT,
--      *PERCEPTION(PSYCHOLOGY), PSYCHOLOGY, PROBLEM SOLVING, MAINTENANCE,
--      TRAINING


CCL >
CCL > more

--                              ******************
--                                EXPORT CONTROL
--                              ******************
--    2   OF    20
-- 1 -  AD NUMBER: E801452L
-- 3 -  ENTRY CLASSIFICATION:   UNCLASSIFIED
--23 -  DESCRIPTORS:      *HUMAN FACTORS ENGINEERING, *ARTIFICIAL
--      INTELLIGENCE, *WORK MEASUREMENT, PERCEPTION, COGNITION, PSYCHOLOGY,
--      INTERFACES, MILITARY APPLICATIONS, PERSONNEL SELECTION, PERSONNEL
--      RETENTION, LITERATURE SURVEYS, PERSONNEL DEVELOPMENT
```

```
CCL > more

--    3   OF    20
-- 1 -  AD NUMBER: B108147
-- 3 -  ENTRY CLASSIFICATION:   UNCLASSIFIED
--23 -  DESCRIPTORS:      *PSYCHOLOGY, *ARTIFICIAL INTELLIGENCE, COMPUTER
--      PROGRAMS, PROGRAMMING LANGUAGES, HUMAN FACTORS ENGINEERING,
--      HARDENING, PHYSICS, MANAGEMENT


CCL > !ls
Makefile        dodisplay.c     dopage.o        getword.c       a1
SAVE/           dodisplay.o     doshell.c       getword.o       waitccl.c
askchoice.c     dofind.c        doshell.o       help/           waitccl.o
askchoice.o     dofind.o        dostart.c       keys.c          writes.c
ccl.h           dohelp.c        dostart.o       keys.o          writes.o
ccl.o           dohelp.o        dostop.c        lex.l           y.tab.h
ccl.y           dolist.c        dostop.o        lex.o
dochoose.c      dolist.o        drols*          main.c
dochoose.o      dopage.c        drols_logon     main.o

CCL > !
1 % who
bsteele  ttyh1   Mar 13 08:09
gillelan ttyhb   Mar 13 08:20
pderamo  ttyhc   Mar 13 08:17
Ustyx    ttyhf   Mar 13 08:20
duc      tty10   Mar 13 08:11
njones   tty19   Mar 13 08:03
cschenk  ttyjc   Mar 13 08:20
2 % exit
3 %
CCL > ^D
                ** Goodbye **

You are now back to NAM.


Logging off DROLS.
```

APPENDIX C

PROLOG PROGRAMMING FOR DROLS
FIRST PAGE

drols.pl 1

```
%-----------------------------------------------------------
%       CCL to DROLS translation rules
%-----------------------------------------------------------

% Top level CCL

ccl_cmd         --> forward_cmd,        { dbnl, dbnl }.
ccl_cmd         --> back_cmd,           { dbnl, dbnl }.
ccl_cmd         --> find_cmd,           { dbnl, dbnl, dbend }.
ccl_cmd         --> choose_cmd,         { nonexec}.
ccl_cmd         --> display_cmd,        { dbnl, dbnl }.
ccl_cmd         --> scan_cmd,           { dbnl, dbnl }.
ccl_cmd         --> list_cmd,           { dbnl, dbnl }.
ccl_cmd         --> combine_cmd,        { dbnl, dbnl }.
ccl_cmd         --> sort_cmd,           { dbnl, dbnl }.
ccl_cmd         --> review_cmd,         { dbnl, dbnl }.
ccl_cmd         --> delete_cmd,         { dbnl, dbnl }.
ccl_cmd         --> explain_cmd,        { nonexec }.
ccl_cmd         --> print_cmd,          { dbnl, dbnl }.
ccl_cmd         --> cost_cmd,           { dbnl, dbnl }.
ccl_cmd         --> define_cmd,         { nonexec}.
ccl_cmd         --> undefine_cmd,       { nonexec}.
ccl_cmd         --> whatis_cmd,         { nonexec}.
ccl_cmd         --> execute_cmd,        { dbnl, dbnl }.
ccl_cmd         --> help_cmd,           { nl, nonexec }.
ccl_cmd         --> relate_cmd,         { dbnl, dbnl }.
ccl_cmd         --> save_cmd,           { nl }.
ccl_cmd         --> set_cmd,            { nl }.
ccl_cmd         --> show_cmd,           { dbnl, dbnl }.
ccl_cmd         --> stop_cmd,           { nl }.
%ccl_cmd        --> keep_cmd,           { nl }.
ccl_cmd         --> error_cmd,          { nl, nonexec }.

:- dynamic definition/2.

% Stop command : doing nothing for now
stop_cmd        --> "stop".


% Display forward and backward commands
forward_cmd     --> "forward",   { dbwrite('F') }.
back_cmd        --> "back",      { dbwrite('B') }.

% Other commands
find_cmd        --> "find", " ", terms(X),
                        {
                         remember(find),
                         filename(F),
                         dbwrite('@S'), dbwrite(F), dbwrite('@'), dbnl,
                         dterm(X),
                         dbnl, dbwrite('END')
                        }.

scan_cmd        --> "scan", " ", terms(X),
                        {
                         remember(scan),
                         dbwrite('@DIF@'), nl,
                         termwrite(X), dbwrite('END')
                        }.

choose_cmd      --> "choose", " ", dbname(X),
                        {
                         remember(scan),
                                        abolish(filename, 1),
                                        asserta(filename(X))
                                       }.

choose_cmd      --> "choose",
                       {
                        remember(choose),
                        ch_cmd
                       }.

display_cmd     --> "display",
                       {
                        remember(display),
                        dis_cmd(Dcmd),
                        dis_format(Format),
                        do_format(Dcmd, Format)
                       }.

list_cmd        --> "list",
                       {
                        remember(list),
                        menu_lcmd
                       }.

combine_cmd     --> "combine" ,
                       {
                        comb_cmd
                       }.

sort_cmd        --> "sort",
                       {
                        remember(sort),
                        sort_cmd(Socmd),
                        sort_field(Field),
                        sort_sequence(Sequence),
                       dbwrite(Socmd), nl, termwrite(Field),
                       termwrite(Sequence), dbwrite('END')
                       }.

review_cmd      --> "review",
                       {
                        remember(review),
                        revoption
                       }.

delete_cmd      --> "delete",
                       {
                        remember(delete),
                        del_cmd
                       }.

error_cmd       --> terms([Head| T]),
                   {
                          scrwrite('Illegal usage of the '),
                          scrwrite(Head), scrwrite(' command.'),
                          scrnl, scrnl,
                          scrwrite('The following topics are also available:'),
                          scrnl, scrnl,
                          unix(shell('ls /ai/prolog/explain/drols')),
```

APPENDIX D

DROLS CCL & PROLOG

```
drols.pl                                                        1

Date: Thu May 7 18:40:07 1987
From: duc (Duc Tran)
Subject: CCL/Prolog translator and DROLS

        Enclosed is a saveon session of the CCL translator for DROLS.
        Notice the improvement in the way DROLS KB is loaded. You now
        are put in CCL right away, and DROLS Knowledge Base is loaded
        by typing 'start drols'.

        Allan's remark about "CCL problem" that the users do have to know
        something about the database one is working on is quite accurate with
        our current experiences. I hope that after this CCL/Prolog prototype
        phase is over with five databases we will have time  to reassess and
        perhaps make the "CCL problem"
        less obvious.

        -duc-
Saveon transcript started on Thu May  7 18:26:10 1987
duc[1] % trans


        (Enter

                CCL>  start database

        to load a knowledge base).



        *** Welcome to CCL *****

CCL > start drols
[/ai/prolog/translator/drols.pl consulted (6.650 sec 11824 bytes)]
CCL > choose

        (1) Current Reports
        (2) Technical Reports
        (3) New Accessions Reports
        (4) Work Units

Selection --> 1
CCL > sort

Please enter sort field (separated by space)
 1 2 3

Please enter sort sequence(A or D)
 a
@SCSR@
1
2
3
a
END

CCL > chbose

        (1) Current Reports
        (2) Technical Reports
        (3) New Accessions Reports
        (4) Work Units

Selection --> 2

CCL > sort

        (1)     Sort search results
        (2)     Sort qualified results
        (3)     Sort user file

Selection --> 2

Please enter sort field (separated by space)
 1 2 33

Please enter sort sequence(A or D)
 d
@SOQR@
1
2
33
d
END

CCL > sort

        (1)     Sort search results
        (2)     Sort qualified results
        (3)     Sort user file

Selection --> 3

Please enter sort field (separated by space)
 3 4 5

Please enter sort sequence(A or D)
 a
@SOUF@
3
4
5
a
END

CCL > ^D
*** BYE **

[ End of Prolog execution ]
```

APPENDIX E

NISO COMMON COMMANDS

National Information Standards Organization, Z39, Committee G

Z39.58

Common Command Language for Online Interactive Information Retrieval
Table 1
Primary Command Names and Abbreviations

Command Name	Abbreviation	Function
BACK	BAC	To view data preceding displayed data or items on a list.
CHOOSE	CHO	To select file(s) or database(s) to be searched.
DEFINE	DEF	To create user macros, to rename a command name, or to name a command expression with a word.
DELETE	DEL	To delete search strategies, search sets, search results, PRINT requests, or DEFINEd commands.
DISPLAY	DIS	To view online the results of searches of the database(s).
EXPLAIN	EXP	To obtain information about the system, its use, and its database(s).
FIND	FIN	To enter a search statement.
HELP	HEL	To directly obtain online assistance or instruction specific to the context of the interaction.
KEEP	KEE	To identify and save specific result sets and/or particular records from previous search results.
FORWARD	FOR	To view continuing data, or data following displayed data or items on a list.
PRINT	PRI	To request offline printing.
RELATE	REL	To view terms logically related to search term.
REVIEW	REV	To view search history, i.e., search statements.
SAVE	SAV	To save search strategies for subsequent use.
SCAN	SCA	To view an ordered list of index terms.
SET	SET	To set or override default parameter values.
SHOW	SHO	To view session parameter default values and non-instructional system or session information.
SORT	SOR	To arrange search results by specified field(s).
START	STA	To initiate a session.
STOP	STO	To terminate a session.

Source: NISO87, p.27